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TESTING WEAK-FORM EFFICIENCY AND LONG-TERM CAUSALITY OF THE R.I.P.H EMERGING CAPITAL MARKETS

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Abstract

The main purpose of this research paper is testing weak-form efficiency and long-term causality of the R.I.P.H emerging capital markets, ie Romania, India, Poland and Hungary. The empirical analysis is focused on BET index (Romania), WIG 20 index (Poland), BSE index (India) and BUX index (Hungary) from January 2000 to July 2018. The empirical results revealed that there is no long-term causality between the selected emerging stock markets analyzed during the period of January 2000 to July 2018.
Keywords: efficient market hypothesis, emerging capital markets, international portfolio diversification, behavioral finance, fractal market hypothesis, international linkage, causality

I. INTRODUCTION

In terms of justifying the selection of the international portfolio, we will highlight in the paragraphs below both the similarities and the differences between the markets in Romania, Poland, Hungary and India. Romania, Poland and Hungary are member states of the European Union but reveals different levels of socio-economic development. Moreover, Romania, Poland and Hungary, are all former communist countries in Central and Eastern Europe. Hungary and Romania are neighbors and share a common past in certain key aspects. Nevertheless, Hungary and Poland joined the European Union (EU) in 2004 and Romania became a member in 2007. Moreover, all three countries are full members of NATO. All the three selected European countries are democratic. According to FTSE Country Classifications, data provided on March 2018, there is the following classification of countries: developed, advanced emerging, secondary emerging and frontier. Hungary is included in the category of advanced emerging markets, while Romania is included in the category of frontier markets, but on the Watch List for a possible reclassification from frontier to secondary emerging. On the other hand, Poland is also included in the category of advanced emerging markets, but it will be promoted to developed market status, effective from September 2018.

India is included in the category of secondary emerging and also member of the BRICS group which includes Brazil, Russia, India, China and South Africa. As can be easily noticed, India is perceived as an alternative in case of a Black Swan[1] event based on international portfolio diversification. The Indian stock market is seemingly uncorrelated with the capital markets in Europe and this aspect can lead to significant long-term diversification benefits. Stock market interdependencies are very important in the context of a diversified international portfolio.

This research paper provides a comprehensive investigation of the efficient market hypothesis in terms of emerging capital markets as an extension of previous research studies of the authors. One of the essential assumptions of classical finances implies that investors are rational and they are concerned to select an efficient portfolio a combination of asset classes chosen as to achieve the greatest possible returns over the long term, but under the conditions of a tolerable level of risk. The efficient market hypothesis is based on the "random walk" theory. This approach leads to the quintessence of efficient market theory, which is based on the idea that an efficient market"fully reflect" available information's. The efficient market hypothesis focuses on three main pillars, ie : investor rationality, uncorrelated errors, and the idea that there are no limits to arbitrage. Technically. Arbitrage is defined as "the simultaneous purchase and sale of the same, or essentially similar, security in two different markets for advantageously different prices" (Sharpe and Alexander, 1990). A market is efficient with respect to a set of information if it is impossible to obtain economic profits by trading on the basis of this information set (Ross, 1987).

Fama (1965) stated that : "an efficient market is defined as a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants". On the other hand, Peters (1994) suggested that : "If all information had the same impact on all investors, there would be no liquidity. When they received information, all investors would be executing the same trade, trying to get the same price." Korajczyk (1995) suggested that "the measure of market segmentation tends to be much larger for emerging markets than for developed markets, which is consistent with larger barriers to capital flows into or out of the emerging markets". However, emerging capital markets are characterized by a number of inefficiencies such as: mispricings (Korajczyk, 1995), financial frictions, misallocation of financial resources (capital), irrational investment decision making, the impact of informational asymmetry and return anomalies.

The central idea of efficient market hypothesis suggest the fact that stock market security prices always incorporate and reflect all relevant information. According to Fama (1970) the ideal financial market would be guided by the principle that prices provide accurate signals for resource allocation. In other words, the concept of market efficiency implies that security prices

[1] A Black Swan event is extremely rare, unpredictable, unexpected, highly improbable but generates catastrophic effects. The appearance of extreme events can generate major financial losses but it can also lead to abnormal stock market returns.

at any moment of time „fully reflect" all available informations. Fama (1998), also known as the father of efficient market hypothesis argued that : "Consistent with the market efficiency hypothesis that the anomalies are chance results, apparent overreaction to information is about as common as underreaction, and postevent continuation of pre-event abnormal returns is about as frequent as post-event reversal.".

Efficient market hypothesis argued that market provides correct pricing and current prices of securities are close to their fundamental values. Thus, in an efficient market the arbitrage opportunities are rather insignificant. Moreover the paradigm focuses on the premise that it's not possible to outperform the market over the long-term.

An alternative theoretical approach is fractal market hypothesis which is based on chaos theory. Short-term price changes have a predisposition to be more volatile than long-term price trends. Peters (1994) suggested that based on fractal market hypothesis, we can understand why self-similar statistical structures exist, as well as how risk is shared distributed among investors. According to Mandelbrot (2008), in finance, a fractal is not a rootless abstraction but a theoretical reformulation of a down-to-earth bit of market folklore - namely, that movements of a capital or currency all look alike when a market chart is enlarged or reduced so that it fits the same time and price scale. On the other hand, Barberis and Thaler (2002) suggested that behavioral finance is focused on two fundamental parts, ie limits to arbitrage and psychology. Behavioral finance is a psychology-based paradigm which disapproves the rationality of market participants and also suggests that emotional biases, irrational human behaviors or cognitive deviations significantly affects the investment process.

II. LITERATURE REVIEW

The main objective of the literature review is to provide a comprehensive framework of the available literature in the chosen research area. In this respect, we will highlight a series of convergent and divergent theoretical opinions based on heterogeneous empirical studies.

Birau (2012) examined in a comparative manner the weak-form efficiency in the case of two neighboring emerging capital markets, ie Bucharest Stock Exchange (Romania) and Budapest Stock Exchange (Hungary), in the context of global financial crisis. Patel (2016) investigated co-movement based on a diversified international portfolio among certain stock markets such as "BSE" - India, "Hangseng" - China, "MXX" - Mexico, "RTS" - Russia, "BVSP" - Brazil, "FTSE-100" – U.K., "Nikkei" – Japan and "NASDAQ" – U.S.A. Palamalai, Kalaivani and Devakumar (2013) have conducted a research study on stock market integration among major stock markets of emerging Asia-Pacific economies, viz. India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China, and Indonesia. The empirical results have highlighted the existence of stock market interdependencies and dynamic interactions among the selected stock markets which generates short-term investment opportunities based on international portfolio diversification. Tripathi and Shruti (2012) have provided additional empirical findings on inter-linkages of Indian stock market (CNX S&P NIFTY 50 stock index) with advanced emerging markets, ie Brazil (BOVESPA stock index), Hungary (BUX stock index), Taiwan (TAIEX stock index), Mexico (INMEX stock index), Poland (WIG stock index) and South Africa (JSE FTSE stock index) over the period ranging from 1 January 1992 to 31 December 2009 based on Johansen co-integration test and Granger's causality test.

Grambovas (2003) have performed an empirical analysis on the long-run and short-run dynamics between exchange rate fluctuations and equity prices in three European emerging financial markets, Greece, the Czech Republic, and Hungary. The author concluded that the Hungarian and Greek authorities should consider the strong link between foreign exchange and capital markets before taking any policy measures. Chen and Chen (2012) investigated the non-linear causal nexus between stock prices and exchange rates in 12 OECD countries. The author concluded based on the empirical results that a long-run level equilibrium relationship among the exchange rates and stock prices exists in only seven out of twelve countries. Singh and Sharma (2012) have conducted an empirical research study on international inter-linkages between stock markets of Brazil, Russia, India, and China, ie BRIC nations. The empirical results have revealed certain international interactions and the authors concluded that Russian, Indian and Brazilian stock exchanges affects each other and get affected by their own return but non of these affect Chinese stock exchange whether they all get affected by Chinese stock exchange.

III. FINANCIAL DATA SERIES AND APPLIED METHODOLOGY

The continuously-compounded daily returns are calculated using the log-difference of stock markets selected indices as follows :

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \ln(p_t) - \ln(p_{t-1})$$

where p is the daily closing price.

The applied financial econometrics approach includes various research tools such as descriptive statistics, Unit Root Test, Hodrick-Prescott (HP) filter, Augmented Dickey-Fuller stationary test, BDS test and Granger causality test.

The empirical analysis is focused on BET index (Romania), WIG 20 (Poland), BSE (India) and BUX index (Hungary). Financial data series consists of the daily closing prices for each selected index from January 2000 to July 2018 with the exception of legal holidays or other events when stock markets haven't performed any financial transactions.

The basic statistical characteristics of BET index (Romania), WIG 20 (Poland), BSE (India) and BUX index (Hungary) stock indices are represented by the following : Jarque-Bera test's statistic which allows to eliminate the normality of distribution hypothesis, parameter of asymmetry of distribution or Skewness and Kurtosis parameter which measures the peakedness or flatness of the distribution, ie leptokurtic distribution.

The fundamental characteristics of selected indices are represented by the following issues : Jarque-Bera test's statistic which allows to eliminate the normality of distribution hypothesis, parameter of asymmetry distribution or Skewness and Kurtosis parameter which measures the peakedness or flatness of the distribution (leptokurtic distribution). The test Jarque-Bera is based on the following mathematical expressions :

$$JB = n\left[\frac{s^2}{6} + \frac{(k-3)^2}{24}\right] = \frac{n}{6}\cdot(s^2 + \frac{(k-3)^2}{4}), \text{ considering :}$$

$$s = \frac{\hat{\mu}_3}{\hat{\sigma}^3} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{[\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2]^{\frac{3}{2}}} \qquad k = \frac{\hat{\mu}_4}{\hat{\sigma}^4} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{\left[\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2\right]^2}$$

Augmented Dickey-Fuller (ADF) test is used in order to determine the non-stationarity or the integration order of a financial time series. A series noted y_t is integrated of order one, ie $y_t \sim I(1)$ and contains a unit root if y_t is non-stationary, but on the other hand Δy_t is stationary, ie $\Delta y_t = y_t - y_{t-1}$. Moreover, extrapolating the previous expression, a series y_t is integrated of order d, ie $y_t \sim I(d)$ if y_t is non-stationary, but $\Delta^d y_t$ is stationary. Practically, ADF diagnostic test investigates the potential presence of unit roots divided into the following categories : unit root with a constant and a trend, unit root with a constant, but without a time trend, and finally unit root without constant and temporal trend. Theoretically, ADF test is focused on the following regression model :

$$\Delta y_t = c + \beta \cdot t + \delta \cdot y_{t-1} + \sum_{i=1}^{p}\gamma_i \Delta y_{t-i} + \varepsilon_t$$

where p represents the number of lags for which it was investigated whether fulfilling the condition that residuals are white noise, c is a constant, t is the indicator for time trend and Δ is the symbol for differencing. In addition, it is important to emphasize the essence of a stochastic trend that can not be predicted due to the time dependence of residual's variance. Strictly related to the ADF test, if the coefficients to be estimated β and δ have the null value then the analyzed financial time series is characterized by a stochastic trend. The null hypothesis, ie the time series has a unit root is rejected if t-statistics is lower than the critical value.
Augmented Dickey-Fuller test was applied in order to determine the stationarity of the selected financial time series. The null hypothesis is that the selected financial time series contains a unit root and it is implicitly non-stationary. Empirical analysis based on the log-returns of the selected indices reflects the fact that $t_{test\_}ADF < t_{critic}$ (1%, 5%, 10%) so the null hypothesis H_0 is rejected and the analyzed time series is stationary. Simultaneous, it is obtain the following result : Prob (0%) < test levels (1%, 5%, 10%) so the null hypothesis H_0 is rejected and the selected financial time series is stationary.
The BDS test was used in order to determine whether the residuals are independent and identically distributed. BDS test is a two-tailed test and is based on the following hypothesis :

H_0: sample observations are independently and identically distributed (I.I.D.)

H_1: sample observations are not I.I.D., aspect involving that the time series is non-linearly dependent if first differences of the natural logarithm have been calculated.

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The BDS methodology involves a time series x_t for t=1, 2, 3…T based on its m-history $x_t^m = (x_t, x_{t-1}, ..., x_{t-m+1})$ where m is the called embedding dimension. Implicitly, the *correlation integral* (a measure of time patterns frequency) is estimated as follows :

$$C_{m,\varepsilon} = \frac{2}{T_m (T_m - 1)} \sum_{m \le s} \sum_{< t \le T} I(x_t^m, x_s^m, \varepsilon)$$

$$\text{and } C_m(\varepsilon) = \lim_{n \to \infty} C_{m,n}(\varepsilon)$$

where T_m = T-m+1 and $I(x_t^m, x_s^m, \varepsilon)$ represents a binary function which has the following values for i=0, 1, 2…m-1:

$$I(x_t^m, x_s^m, \varepsilon) = \begin{cases} 1 & if \quad |x_{t-i} - x_{s-i}| < \varepsilon \\ 0 & otherwise \end{cases}$$

Brock, Dechert, Scheinkman, LeBaron (1996) argued that the BDS statistics is calculated as follows :

$$V_{m,\varepsilon} = \sqrt{T} \frac{C_{m,\varepsilon} - C_{1,\varepsilon}^m}{S_{m,\varepsilon}}$$

where $S_{m,\varepsilon}$ is defined as the standard deviation of $\sqrt{T(C_{m,\varepsilon} - C_{1,\varepsilon}^m)}$. In addition, the BDS statistics converges in distribution to N(0,1) thus the null hypothesis of independent and identically distributed is rejected based on a result such as $|V_{m,\varepsilon}| > 1{,}96$ in terms of a 5 % significance level.

The null hypothesis was rejected in all sample cases based on selected stock indices. The following outputs highlight the value of the standardised BDS statistics and the corresponding two-sided probabilities. The BDS test was used in order to determine whether the residuals are independent and identically distributed. The BDS statistics converges in distribution to N(0,1) thus the null hypothesis of independent and identically distributed is rejected based on a result such as in terms of a 5% significance level.

The empirical analysis includes the use of Hodrick-Prescott (HP) filter which is a specialized filter for trend and business cycle estimation. Hodrick-Prescott filter has a wide applicability in economics. The basic idea suggests that in the center of the sample financial time series the filter is symmetric and towards the end of the series is becoming increasingly asymmetric. On the other hand, Hodrick-Prescott filter involves the decomposition of the sample financial time series into a trend component and a residual component, which may or may not include a cyclical component.

Granger (1969) argued that if some other time series Yt contains informations regarding the past periods which are useful in the prediction of Xt so this informations are included in no other series used in the predictor, then this implies that Yt caused Xt. In addition, Granger argued that if X_t and Y_t are two different stationary time series variables with zero means, then the canonical causal model has the following form :

$$X_t = \sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t$$

$$Y_t = \sum_{j=1}^{m} c_j X_{t-j} + \sum_{j=1}^{m} d_j Y_{t-j} + \eta_t$$

where ε_t and η_t play the role of two uncorrelated white-noise series, namely $E[\varepsilon_t \varepsilon_s] = 0 = E[\eta_t \eta_s]$ for $s \neq t$ and on the other hand $E[\varepsilon_t \varepsilon_s] = 0$ for $\forall t, s$. Practically, the basic concept of causality requires that in the case when Y_t is causing X_t some b_j is different from zero and vice versa, ie in the case when X_t is causing Y_t some c_j is different from zero. A different situation implies that causality is valid simultaneously in both directions or simply a so-called "feedback relationship between X_t and Y_t". The F-distribution test is used to test the Granger causality hypotheses based on the following formula :

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)}$$

where RSS_R is the residual sum of squares, RSS_{UR} is the unrestricted residual sum of squares, m is the number of lagged X_t variables, K is the number of parameters in the restricted regression. The null hypothesis Ho implies that lagged X_t terms do not belong in the regression. The null hypothesis is rejected if the F-value exceeds the critical F value at the selected level of significance (5%) or if the P-value is lower than the α level of significance.

IV. EMPIRICAL RESULTS

The empirical analysis is focused on BET index (Romania), WIG 20 index (Poland), BSE index (India) and BUX index (Hungary) from January 2000 to July 2018. The analyzed period is a very long interval that incorporates daily closing price of selected stock indices. The individual trend of selected indices mentioned above was very fluctuating, even strongly decreasing in all four cases in correlation with the impact of the global financial crisis (see Fig. 1). Financial time series exhibit time variation in mean and variance, so exhibit a non-stationary behavior, requiring to be transformed to stationary series. The financial time series adapted to econometric requirements are based on continuously compounded returns. The continuously compounded returns calculated for selected stock indices, respectively BET index (Romania), WIG 20 index (Poland), BSE index (India) and BUX index (Hungary) is graphically represented in the figures no. 2 (joint graphics) and no. 3 (individual graphics) included in Appendices.

A basic characteristic feature of emerging capital markets is that the distribution of continuously compounded returns deviates from the normal distribution or Gaussian distribution. The

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histograms of the analyzed stock market indices have been included in Appendices (see Fig.6). The empirical analysis also focuses on Skewness and Kurtosis based on data distribution. Statistically, skewness is a measure of asymmetry of the distribution of a financial data series around its means but the skewness of a symmetric distribution is zero. Taking into account the financial implications of efficient markets hypothesis it is obvious that in the case of normal distribution, the skewness is null. Positive skewness highlights that the distribution has a long right tail, while negative skewness implies that the distribution has a long left tail. Kurtosis measures the peakedness or flatness of the distribution of a return financial data series. The kurtosis of a normal distribution is 3, but if the kurtosis exceeds 3, the distribution is peaked (Leptokurtic) relative to the normal. Moreover, if the kurtosis is less than 3, the distribution is flat (Platykurtic) relative to normal. The empirical results revealed that in all four cases, respectively for BET index (Romania) is -0,433526, for WIG 20 index (Poland) is -0,138691, for BSE index (India) is -0,164621 and for BUX index (Hungary) is -0,040782 indicate the existence of negative skewness which implies that the distribution has a long left tail. The kurtosis exceeds 3 in all four cases, respectively for BET index (Romania) is 10,57696, for WIG 20 index (Poland) is 5,624807, for BSE index (India) is 11,41479 and for BUX index (Hungary) is 9,003293 so that the distribution is peaked (Leptokurtic) relative to the normal.

The Augmented Dickey-Fuller test was applied in order to determine the stationarity of selected financial time series. The empirical results obtained based on continuously compounded returns indicate that the null hypothesis H_0 is rejected in all four cases because $t_{test\_ADF} < t_{critic}$ (1%, 5%, 10 %) which implies that all the analyzed time series are stationary. We also can use the formula Prob (0 %) < test levels (1%, 5%, 10 %) which leads to the same conclusion that all the analyzed time series are stationary (see Table 1).

The BDS test was performed in order to determine whether the residuals are independent and identically distributed. The null hypothesis is rejected if the BDS test statistic is greater than or less than the critical values. The level of significance, respectively, a of 5 % (if a = 0.05, the critical value = ±1.96) is considered in this hypothesis testing. In the case of continuously compounded returns, the null hypothesis was rejected in all four cases (see Table 2).

Applying Granger causality test, the null hypothesis is rejected if the F-value exceeds the critical F value at the selected level of significance (5%) or if the P value is lower than the α level of significance. The financial data series of BET index (Romania), WIG 20 index (Poland), BSE index (India) and BUX index (Hungary) from January 2000 to July 2018 based on continuously compounded returns indicate that there is no causality between the following pairs of emerging stock markets, in the sample period, ie : Romania and India, Hungary and India, Poland and India, Romania and Hungary, Poland and Hungary respectively Poland and Romania (see Table 3).

V. CONCLUSIONS

This particular research paper provides additional empirical evidence of emerging capital markets behavior in order to diversify the investment risk. Efficient market hypothesis has as quintessence random walks which implies the requirement of unit roots. The empirical analysis revealed that ADF t statistics rejected the null hypotheses of a unit root so the selected financial

data series are stationary. The efficient market hypothesis has not been validated, not even the weak-form efficiency during the selected time interval from January 2000 to July 2018 based on continuously compounded returns. Moreover, empirical results also revealed that there is no long-term causality between the selected emerging stock markets, ie Romania, India, Poland and Hungary during the period of January 2000 to July 2018. A further extention of this research paper will focus on investigating co-movements and inter-linkage between developed and emerging capital markets based on international portfolio diversification.
Birau (2012) reached similar conclusions, ie that efficient market hypothesis is not accomplished, not even the weak-form efficiency, during the period of January 2007 to November 2011, both for Bucharest Stock Exchange and Budapest Stock Exchange. According to Tripathi and Shruti (2012), the empirical results based on Granger causality test results revealed unidirectional relationship of precedence in most cases, ie the Indian stock market was found to be positively and significantly correlated with all the advanced emerging markets for total time period (from 1 January 1992 to 31 December 2009). Patel (2016) suggested that RTS (Russia) has dependency on the FTSE-100 (UK) and Hangseng (China), while RTS depend on FTSE 100, and meanwhile FTSE 100 is affected by BVSP, MXX and NASDAQ, whereas Hangseng is affected by BSE, BVSP, FTSE 100, MXX and NASDAQ, but concurrently Granger causality test indicates that the BSE is Granger caused by BVSP, FTSE 100, MXX, NASDAQ and the RTS stock market.

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APPENDICES

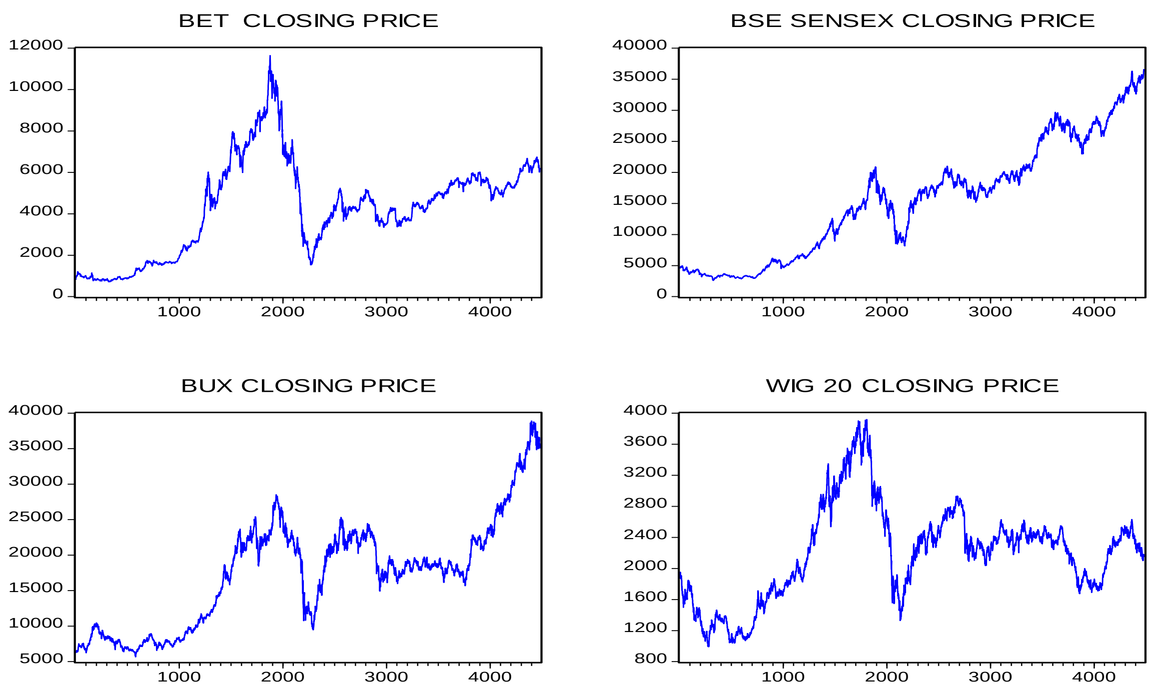

Fig. 1 The trend of R.I.P.H stock indices - individual graphics –
Source: Author's own computations based on selected financial data series

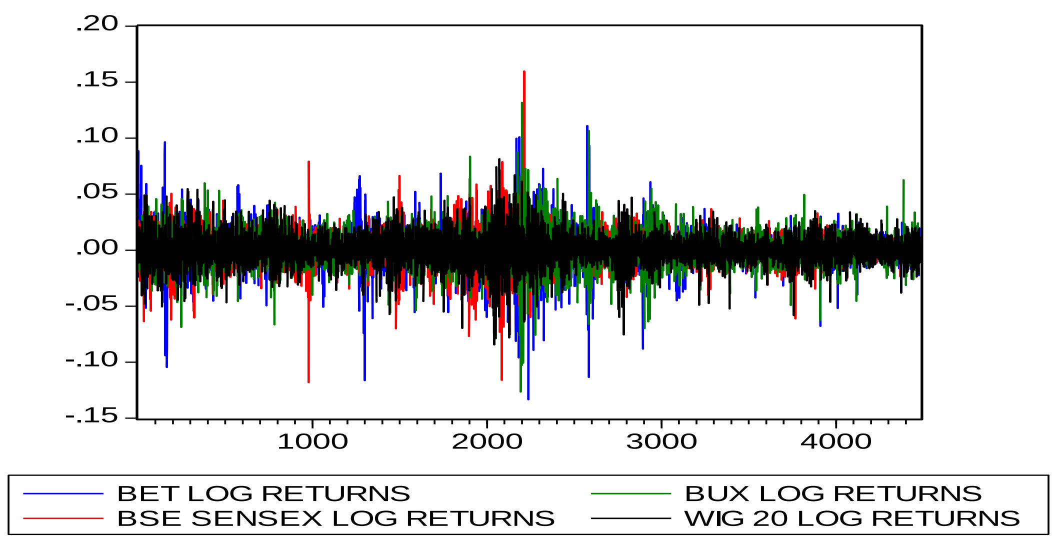

Fig. 3 : The log-returns of R.I.P.H stock indices - joint graphics
Source: Author's own computations based on selected financial data series

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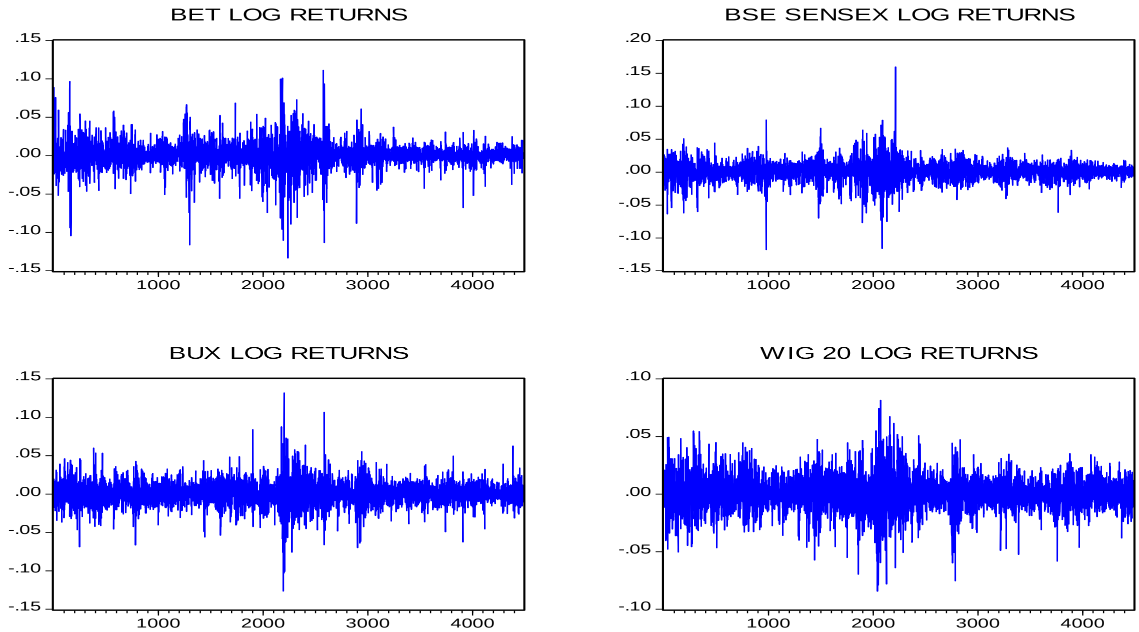

Fig. 2 Log returns series of R.I.P.H stock indices - individual graphics
Source: Author's own computations based on selected financial data series

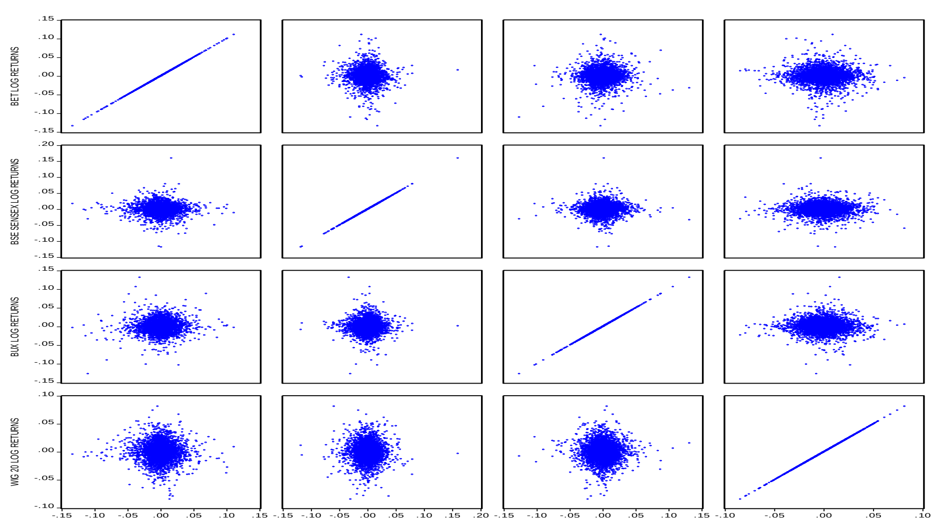

Fig. 3 : Matrix of all pairs of selected stock market indices
Source: Own computations based on selected financial data series

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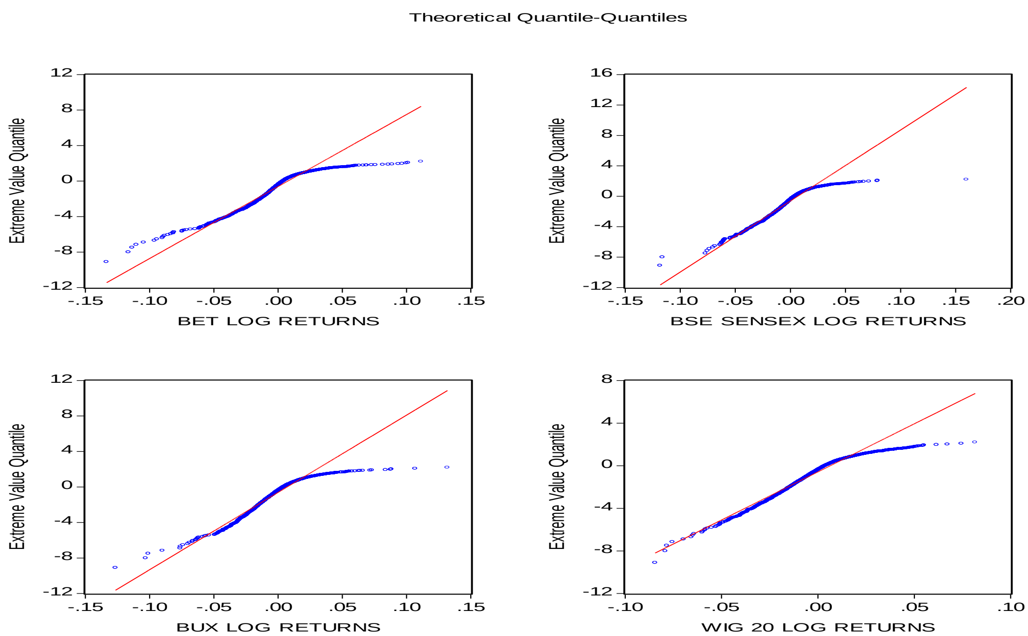

Fig. 4 : Theoretical Quantile-Quantile Plots (Extreme values)

Source: Own computations based on selected financial data series

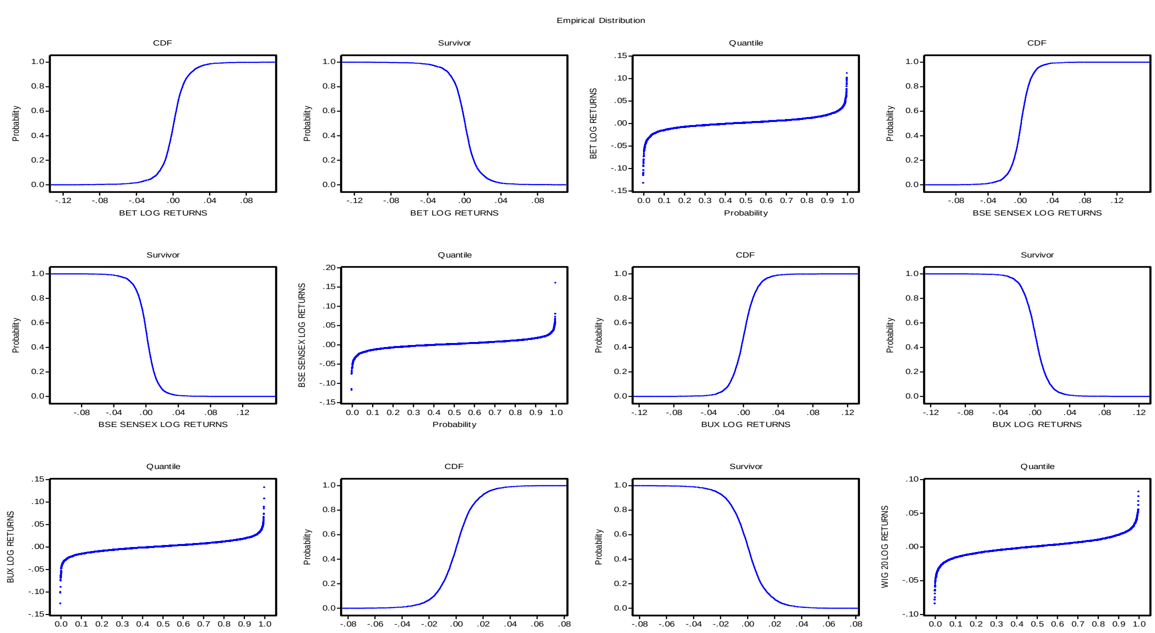

Fig. 5 : Distribution graphics CDF - SURVIVOR – QUANTILE

Source: Own computations based on selected financial data series

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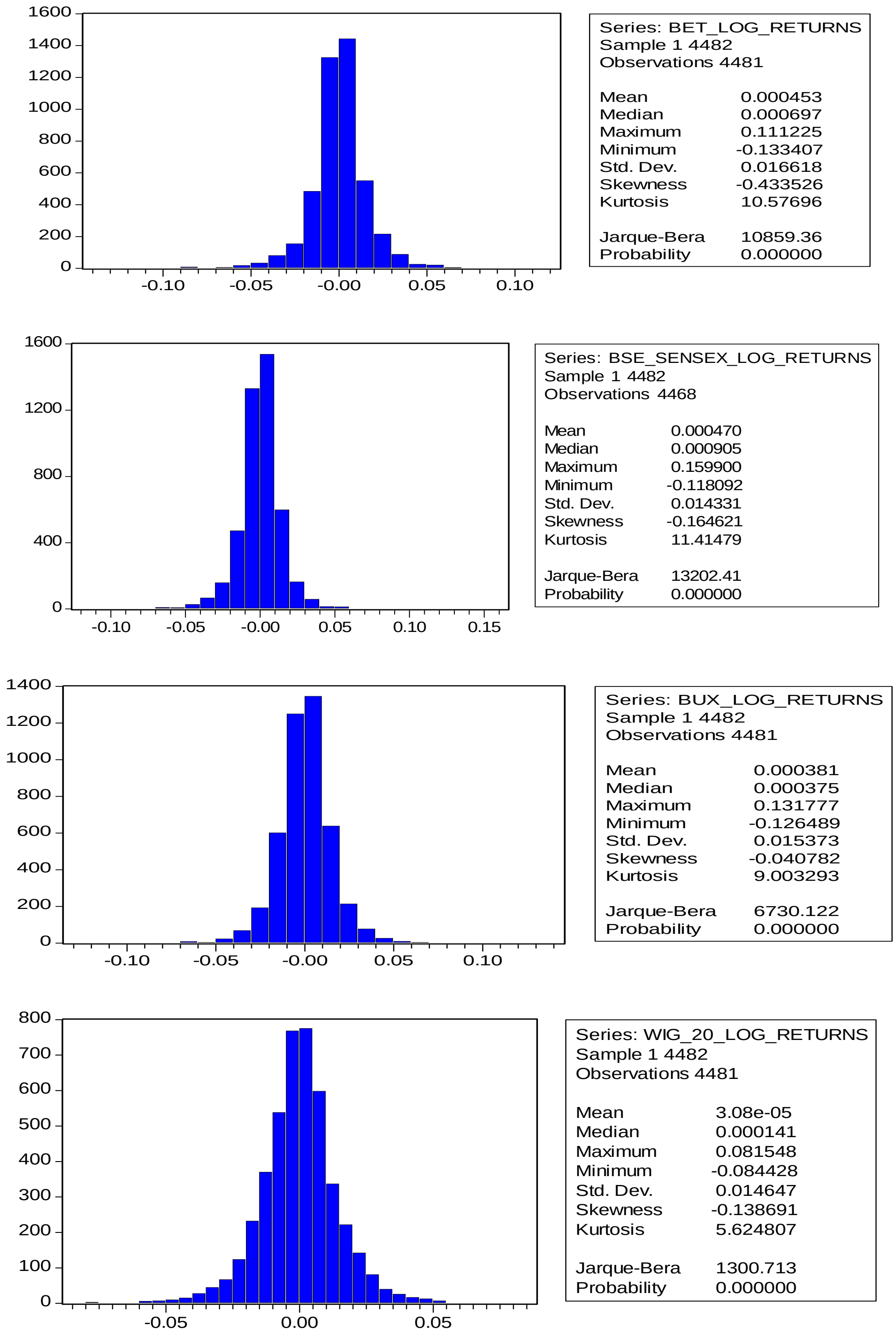

Fig.6 : Basic statistical characteristics of R.I.P.H stock indices

Source: Own computations based on selected financial data series

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Table 1: Augmented Dickey-Fuller (ADF) Test

Null Hypothesis: BET_LOG_RETURNS has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-59.97641	0.0001
Test critical values:	1% level	-3.431626	
	5% level	-2.861989	
	10% level	-2.567052	

Null Hypothesis: BSE_SENSEX_LOG_RETURNS has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-47.62223	0.0001
Test critical values:	1% level	-3.431628	
	5% level	-2.861990	
	10% level	-2.567052	

Null Hypothesis: BUX_LOG_RETURNS has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.81521	0.0000
Test critical values:	1% level	-3.431627	
	5% level	-2.861989	
	10% level	-2.567052	

Null Hypothesis: WIG_20_LOG_RETURNS has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-63.93847	0.0001
Test critical values:	1% level	-3.431626	
	5% level	-2.861989	
	10% level	-2.567052	

Source: Own computations based on selected financial data series

Table 2 : BDS Test

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BDS Test for BET_LOG_RETURNS

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.039934	0.001498	26.65707	0.0000
3	0.075117	0.002377	31.60700	0.0000
4	0.099804	0.002826	35.31842	0.0000
5	0.113540	0.002941	38.60188	0.0000
6	0.119716	0.002833	42.25958	0.0000

BDS Test for BSE_SENSEX_LOG_RETURNS

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.025242	0.001389	18.16931	0.0000
3	0.050943	0.002204	23.11541	0.0000
4	0.069495	0.002620	26.52455	0.0000
5	0.080448	0.002726	29.50674	0.0000
6	0.085304	0.002625	32.49391	0.0000

BDS Test for BUX_LOG_RETURNS

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.015466	0.001263	12.24557	0.0000
3	0.031003	0.002003	15.48164	0.0000
4	0.042230	0.002379	17.74926	0.0000
5	0.049011	0.002474	19.80900	0.0000
6	0.051446	0.002381	21.61042	0.0000

BDS Test for WIG_20_LOG_RETURNS

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.010641	0.001296	8.210468	0.0000
3	0.023092	0.002054	11.24055	0.0000
4	0.034389	0.002440	14.09313	0.0000
5	0.042110	0.002537	16.59927	0.0000
6	0.046230	0.002440	18.94404	0.0000

Source: Own computations based on selected financial data series

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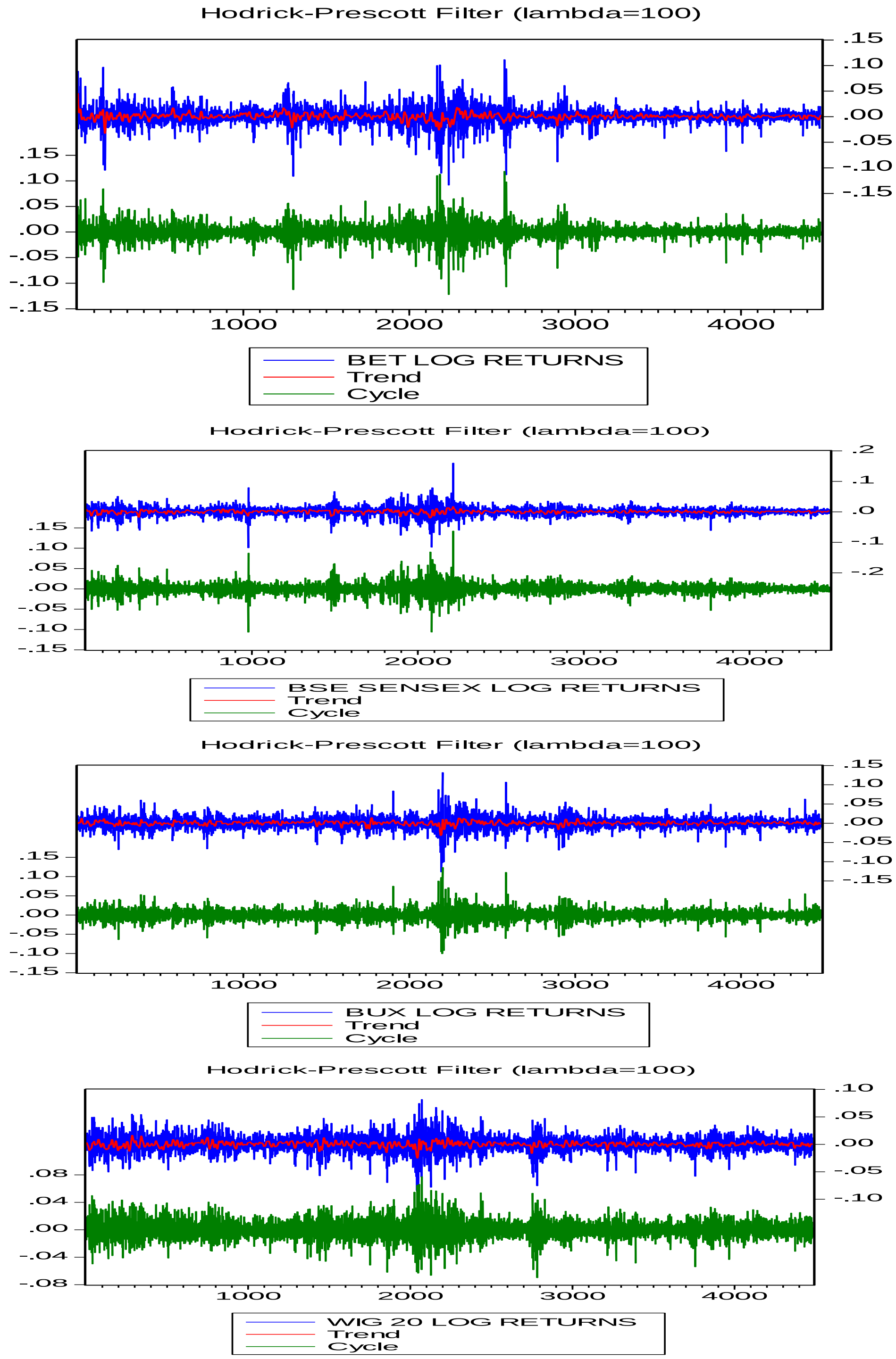

Fig. 6 : Hodrick – Prescott Filter

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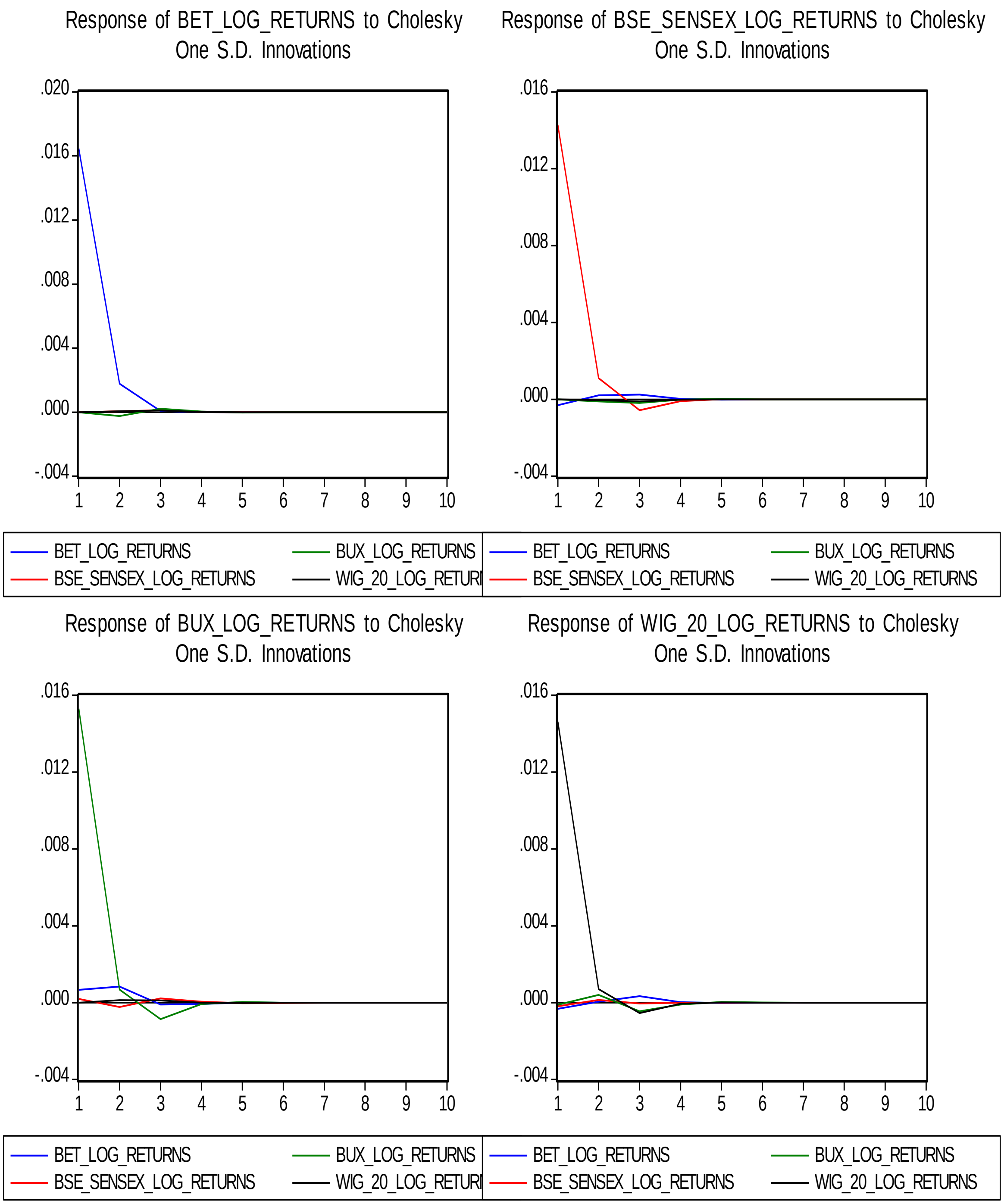

Fig. 9 Impulse Response Analysis to Cholesky One S.D. Innovations
Source: Own computations based on selected financial data series

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Table 3 : Granger Causality tests

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Probability
BSE_SENSEX_LOG_RETURNS does not Granger Cause BET_LOG_RETURNS	4478	0.54388	0.65227
BET_LOG_RETURNS does not Granger Cause BSE_SENSEX_LOG_RETURNS		0.65625	0.57897
BUX_LOG_RETURNS does not Granger Cause BET_LOG_RETURNS	4478	0.87271	0.45440
BET_LOG_RETURNS does not Granger Cause BUX_LOG_RETURNS		4.43097	0.00408
WIG_20_LOG_RETURNS does not Granger Cause BET_LOG_RETURNS	4478	0.09808	0.96111
BET_LOG_RETURNS does not Granger Cause WIG_20_LOG_RETURNS		0.94982	0.41552
BUX_LOG_RETURNS does not Granger Cause BSE_SENSEX_LOG_RETURNS	4478	2.63009	0.04847
BSE_SENSEX_LOG_RETURNS does not Granger Cause BUX_LOG_RETURNS		0.88113	0.45002
WIG_20_LOG_RETURNS does not Granger Cause BSE_SENSEX_LOG_RETURNS	4478	1.41259	0.23706
BSE_SENSEX_LOG_RETURNS does not Granger Cause WIG_20_LOG_RETURNS		0.78400	0.50270
WIG_20_LOG_RETURNS does not Granger Cause BUX_LOG_RETURNS	4478	1.91021	0.12564
BUX_LOG_RETURNS does not Granger Cause WIG_20_LOG_RETURNS		3.45349	0.01582